# 11

# Orchestrating Appropriability: Towards an Endogenous View of Capturing Value from Innovation Investments

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## Introduction

In this chapter, we revisit the motivating question of Teece's seminal (1986) paper: why do some firms profit from their innovation investments, whereas others do not? Teece's answer, as we will review below, blended elements of technological characteristics (particularly the character of knowledge), the degree of appropriability conveyed through intellectual property (IP), and the nature of the complementary assets required to commercialize the innovation.

In Teece's account, firms operating in 'tight appropriability regimes' would be able to capture value from their innovation investments, whereas firms operating in 'weak' regimes would be at risk of failing to do so. He took the degree of appropriability to be exogenously determined, as have scholars conducting empirical research on perceived appropriability within industries (Levin, *et al.*, 1987).

Yet Teece's own insight into complementary assets suggests that a firm's own actions can ameliorate the appropriability problem. If the firm owns or can access the requisite complementary assets, the firm may profit from innovation activities even in weak appropriability regimes. This motivates the present chapter, in that it points the way toward firm actions that can alter the degree of appropriability in their industry. To put it differently, it suggests that appropriability may be endogenously determined – at least to some degree.

This is a potentially important contribution to the strategic management literature, which has largely followed Teece, Levin *et al.*, and others, in treating appropriability as exogenous. It may also explain potential anomalies in the exogenous view of appropriability, such as the apparent ability of some firms in an industry to protect their ideas, processes, and technologies, whereas other firms in the same industry appear to be unable to do so.

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The next section of the paper will review the role of appropriability in the strategic management literature. Then, we explore some specific mechanisms that are largely or entirely under the control of the firm's managers, which directly affect the degree of appropriability of a firm's innovation investments. The fourth section considers the potential costs of these endogenous mechanisms, with particular attention paid to complementary assets. The final section brings the various mechanisms together, to explore possible orchestration strategies that collectively enhance the appropriability of a firm's innovation investments.

## Appropriability and Firm Strategy

So, why do some firms profit from their innovation investments, whereas others do not? As Teece (1986) noted, the aim of his article was 'to explain why a fast second or even a slow third might outperform the innovator' (p. 285). Teece's answer to the question blended elements of technological characteristics (particularly the character of knowledge), the degree of appropriability conveyed through IP, and the nature of the complementary assets required to commercialize the innovation. Firm strategy, in turn, needed to take all these core parameters into account.

The story of EMI in medical CT scanners was the archetypal example in Teece (1986). Its initial successful entry into this new category demonstrated the utility of its innovation. Yet its subsequent failure revealed the company's inability to access the requisite complementary assets, and – importantly for our purposes – its failure effectively to leverage IP to stay ahead of the followers. The followers were able to move in, and take over the industry. 'By 1978, EMI has lost market leadership to Technicare which in turn was quickly overtaken by GE. . . . Though royalties continued to flow to EMI, the company had failed to capture the lion's share of the profits generated by the innovation it had pioneered and successfully commercialized.' (Teece, 1986, pp. 298–9). EMI and Technicare were replaced by GE, owing to the latter's superior marketing and sales channels, as well as GE's superior manufacturing capability. Teece termed these 'complementary assets' (Teece, 1986).

Complementary assets can be generic, specialized, or co-specialized (Teece, 1986). Generic assets are easy to replicate, and hence are not a source of competitive advantage. Specialized and co-specialized assets are difficult to replicate, and are a type of specific asset in Williamson's (1985) conception. These are the assets of potential strategic importance. The value of this complementary asset is the sum of its specific use, plus its residual value in its next best alternative use, as well as any generic use. This is shown in Figure 11.1.

As shown in the figure, the key value in a complementary asset derives from its quasi-rent, the amount of value gained by deploying the asset in its specialized use, as opposed to the value gained in the next-best use.

In this chapter, we pay particular attention to intermediate markets, whereby an upstream technology supplier licenses its know-how and IP to downstream developers and producers.[1] In these markets, the question of appropriability is

[1] See Teece (2000) and Arora, Fosfuri, and Gambardella (2001).

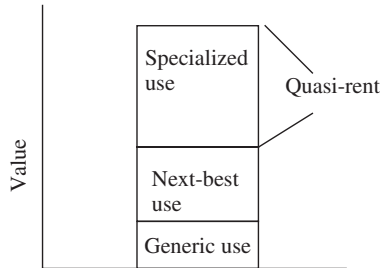


FIGURE 11.1 Partitioning the value of a specialized complementary asset.

more nuanced and intriguing than in the EMI scanner story above, in large part because the ownership of the requisite knowledge assets, complementary assets, and IP assets may all lie in different hands. As intermediate markets grow in importance in industries ranging from software, semiconductors, and telecommunications, to petroleum engineering, an increasing number of situations have emerged wherein the owner of the technology, the owner of the complementary assets, and the owner of the requisite IP all differ. These different owners with their respectively different assets influence these markets for technology, and in turn, affect the appropriability of innovation investments.

Before teasing apart these different assets, it will be useful to review some prior empirical literature that examined the role of complementary assets in firm strategy. No attempt has been made to compile exhaustively every study in this vein. Instead, illustrative studies have been chosen that provide a rich internal view of complementary assets. Each study supports the importance of complementary assets but also illustrates an endogenous component to those complementary assets.

### *Selected prior empirical studies of complementary assets*

Mitchell (1989) examined the effect of innovation upon firms in the medical diagnostic equipment industry. He probed the emergence of new subfields within medical equipment, which were enabled by technical advances in imaging and related technologies. The causal mechanism driving his analysis was based upon economic incentives. The firm's incentive to enter was contingent on the costs of delay (firms rationally want to wait and see what the risks and benefits of entry might be, particularly if the new subfield might substitute for sales of their current products), versus the risks of being pre-empted by the entry of rival firms, who might become entrenched before the firm could establish itself in the new field (if the firm waited too long). Here the appropriability of investments was determined by the interplay of the costs of delay versus the costs of pre-emption.

In one carefully constructed analysis (Mitchell, 1989),[2] he found evidence that incumbents that perceive a threat to their core products are more likely to enter. He

[2]One example of Mitchell's more thorough analysis is his explicit treatment of the issues of right-censorship, i.e., the condition where a firm is in the sample but has not (yet) entered a new subfield.

also reported findings that incumbents that possess relevant complementary assets are more likely than other rivals to enter into a new subfield. Mitchell (1992) later extended this research by explicitly comparing and contrasting the role of market-related supporting assets (such as a direct sales force) to the role of technically related assets, such as prior experience in similar technological areas, in the behavior of medical equipment firms. He found evidence indicating that market-related assets were associated with greater incumbent survival, and with higher market shares, whereas incumbents with prior technical experience encounter a more mixed set of outcomes. Prior technical experience exhibited a slightly negative effect upon incumbent survival and short-term share. The 1992 study found that prior technical experience may impair incumbents' initial adaptation to innovation, resulting in a 'trap' (p. 342) within an inferior technical trajectory, and 'mistakes' (p. 343). This hints at one of the potential downsides for developing and maintaining complementary assets (here, prior technical experience): they may impose costs of their own that constrain later adaptation.

A research program by Tripsas (1997) examined the impact of technological change in the typesetter industry. Tracking the events of a century in that industry, she identified three separate waves of technical change that hit the firms in the industry. Interestingly, although these changes were quite extensive, not all the leaders in the industry were displaced. Many firms indeed were driven out, but a few persisted.

This persistence prompted her to examine the mechanisms that appeared to promote this longevity, despite the turbulent technical environment. She found that the presence or absence of key complementary assets (Teece, 1986) such as manufacturing, sales networks, and font libraries, enhanced the ability of incumbent firms to survive the technological shift (Tripsas, 1997). She also found that firms with 'external integrative capability' were better able to respond to nonincremental innovation shocks. This integrative capability included internal investments in research and development that improved the firm's absorptive capacity to access knowledge from the external environment. It also included investments in transferring knowledge throughout the firm, particularly investments that promoted the sharing of knowledge across functional groups such as R&D, manufacturing, and sales.

A final mechanism Tripsas found of enhanced longevity was the existence of dispersed research sites in different locations. These different sites appeared to stimulate rivalry between the sites on the one hand, and promoted greater variation in technological approaches that a firm pursued on the other hand. Thus, although technological changes rendered the technology of one research site obsolete, the different technical path of another site sometimes enabled the incumbent firm to shift to that technology platform at the other site, instead of fighting a losing battle to sustain the now-obsolete technology base. It is perhaps obvious, but nonetheless worth noting, that the knowledge transfer mechanisms and the maintenance of multiple R&D sites are again entirely determined by actions of a given firm, not by some exogenous factor.

In work with Joseph Bower (Christensen and Bower, 1996), Christensen linked the disruption of the *external* value network to the inertia created by the *internal* resource allocation process inside incumbent hard disk drive firms (see also Christensen, 1997). They showed that established disk drive firms listened carefully to their established customers, and their internal resource allocation procedures channeled funds among competing projects towards those projects that served these established customers. When architectural changes such as new form factors emerged that served their established customers, they found that US incumbent hard disk drive firms had little difficulty adjusting to the new technology. This type of technology they termed 'sustaining'. When new form factors emerged that served different customers in remote markets that did not interest current customers, though, these same incumbents were late to enter the new form factors, and were generally ineffective when they did enter. This type of technology was termed 'disruptive'. Christensen essentially argued that firms could readily appropriate the value of sustaining investments, although they were unlikely to do so with disruptive investments. Here, appropriability was not dependent upon exogenous factors, but instead upon the internal tensions in allocating resources within the firm.

Sull (1997; Sull *et al.*, 1997) has published results from a detailed study of incumbent behavior in the US tire industry. There are at least two characteristics of this research program that are relevant to the question of appropriability. One is that the technology transition from bias ply to radial ply tires that Sull studied was an obvious transition to incumbent tire manufacturers. Because it was signaled well in advance of the event, and because it was not a particularly complex technological change, the usual cognitively limited causal explanations for incumbent difficulties with technology transition (e.g., Henderson and Clark, 1990) ought not to apply. Incumbents ought to have known what was coming, and ought to have known what to do to respond to it, well in advance of having to do it.

The other salient characteristic of this research program is that Sull had unusually deep access to internal records of the incumbent tire firms, and so was able to reconstruct detailed records of investment at the individual tire plant level for each of the US incumbent firms. This unusually detailed evidence indicated that, despite the obvious character of the technical shift, US incumbent tire firms nonetheless stumbled badly in responding to the radial technological transition. The causal explanation he offered for this finding derived from the commitments that management at each incumbent firm had to stakeholders of each firm, including customers, employees, and the surrounding community. In other contexts, analysts often praise firms for 'high commitment workforce policies', and for 'staying close to the customer' (Peters and Waterman, 1982). Presumably these commitments were also appropriate for the US tire industry at an earlier point in time. By the time of the advent of radial tires, though, these commitments prevented incumbent firms from taking actions such as tire plant closures or conversions that would have preserved many hundreds of millions of dollars in shareholder value. Note that these commitments were internally constructed by the actions of the US tire firms, and were not imposed by some exogenous circumstance.

Stepping back from these individual empirical studies, it is clear that the appropriability mechanisms that each identified emanated more from internal actions of focal firms, than they did from overall industry-level characteristics. In Mitchell's and especially in Sull's work, it is also clear that the actions that firms took to enhance the appropriability of their innovation investments at one point in time, later became a source of strategic inertia for the firm.

## Endogenous Appropriability Mechanisms: Implications for Strategy

Strategy has been argued by many to be the search for rents (Williams, 1994). The work of Michael Porter (1980; 1985) established a source of rents from entry barriers into an industry, along with switching costs faced by consumers. Porter's analysis, in turn, was informed by a longstanding literature in industrial organization, spearheaded by the work of Bain (Caves and Porter, 1977; Gilbert, 1989).

An even older stream of economic analysis by David Ricardo identified the role of scarcity in creating rents. This venerable insight has been rediscovered by the resource-based view (RBV) of the firm (Wernerfelt, 1984; Barney, 1989; Mahoney and Pandian, 1992). Building on the observation by Rumelt (1982) that profitability varied within an industry as much or more as it did between industries, this approach seeks to understand the sources of variation in rents between firms in the same industry. In the RBV construction, strategic rents come from assets that are inimitable, or difficult to imitate. This is simply scarcity by another name, albeit now in an advanced industrial economic context. Assets that are easily imitated or readily exchanged cannot be a source of sustainable advantage. The RBV analysis identified the source of Ricardian rents to come from within the firm, rather than from the Porterian rents arising from the external entry barriers to an industry.

The Teece (1986) analysis and the subsequent development of dynamic capabilities (Teece, Pisano, and Shuen, 1997) identify a third source of strategic rents for the firm. These are Schumpeterian rents, the rents that arise from innovation. These do not arise from incremental innovation; rather, they derive from the Schumpeterian innovation that 'strikes at the very lives' of established firms. These rents are rooted in fundamentally improved products and processes. Like the Ricardian rents of the RBV approach, these rents also emanate from within the firm. Unlike the Ricardian rents, though, these rents are likely to be transient, as the waves of innovative activity overtake and make obsolete previous improvements in products and processes. In contrast to the static conceptions of 'industry' that underlie Porterian strategy, the Schumpeterian innovation process is dynamic, showing scant regard for current industry boundaries, and eroding previously high industry barriers in its wake (while possibly throwing up new barriers).

Although we follow this last line of analysis in identifying the sources of rents, the analysis does not go far enough into the actions of firms that can influence those rents. Therefore, the next section considers the potential separation of complementary assets from the IP that undergirds those assets.

## The Potential Costs of Complementary Assets When IP is Separately Owned

In 1995, the US Department of Justice (DOJ) issued its guidelines licensing IP.[3] These guidelines drew a distinction between the market for goods, the market for technology, and the market for innovation. The market for goods relates to product market offerings. The market for technology involves the trading of IP, while the market for innovation involves the conduct of research that may lead to future development of products and services. Here we will to focus on the second category, the market for technology, or the market for knowledge assets in our terminology. As discussed in Teece (1982; 1998), Gans, Hsu, and Stern (2002), and Arora, Fosfuri, and Gambardella (2001), this can be conceived to be a market lying upstream from producers of goods and services in the product market, and the presence of this upstream market may have powerful effects on innovation within the industry of the upstream and downstream firms.

Implicit in the dynamic capabilities analysis is the assumption that the IP that supports Schumpeterian innovation is fully controlled by the innovating firm, as in Teece (1986). This does not consider situations such as those contemplated in the DOJ guidelines above, where IP ownership may differ from the ownership of the requisite knowledge assets and complementary assets, and where this separation may create blocking situations that impede the innovating firm. Yet Teece himself made the conceptual distinction in one of his early articles (Teece, 1982). More recently, he has begun to tease apart the innovation of a given firm from the intellectual capital that underlies this innovation.[4] This distinction leads to additional insights in the challenge of profiting from innovation. Under certain conditions, it also leads to insights that qualify the findings of the Teece (1986) article. We argue below that the dimension of IP affects the apportionment of Schumpeterian rents from innovation.

Teece's 1986 paper implicitly assumed that the owner of the knowledge assets and the complementary assets also controlled the relevant IP that pertained to those assets. In GE's case, this was probably the case, as it had a strong internal R&D program, supported by a large patent portfolio in medical equipment technology, manufacturing processes, trademarks for its brands, and so on. However, the emergence of intermediate markets creates conditions where that ownership of the knowledge assets, the IP assets, and complementary assets need not coincide.

Consider the case of Qualcomm in cellular telephony, or of Rambus in high transfer speed DRAM devices. In each instance, the technology supplier (Qualcomm or Rambus) has developed a new and valuable technology. This lead to substantial know-how, as well as IP assets (primarily patents). Each company licenses these assets to manufacturers of cell phones or DRAMs, respectively. The licensee must still develop the final product, manufacture the product, and market and sell the product. So the licensee must own or have access to the usual complementary assets

[3] US Department of Justice, Antitrust Guidelines for the Licensing of Intellectual Property, Washington, DC, Department of Justice: Federal Trade Commission, April 6, 1995.

[4] See Teece's 1998 article 'Capturing value from knowledge assets', which won the Accenture award, and his 2000 book *Managing intellectual capital*.

in Teece's sense of the term, and yet the licensee must further access knowledge assets and IP assets from a technology supplier.

In addition to intermediate markets, there are a number of other circumstances that can cause a firm practicing a technology (and therefore has the requisite know-how to utilize an innovation) not to have the necessary IP rights to protect its ability to continue to operate. One instance is due to the ambiguity of patent claims granted by the patent authorities, which takes time and money to resolve.[5] This ambiguity can be exploited to block, or impair, a competitor. It can also arise where a firm has misappropriated a technology (wittingly through unauthorized copying,[6] or unwittingly through parallel discovery and deployment). It can even arise when a company pursues an innovation opportunity, but neglects to file for relevant legal protection of the IP undergirding its pursuit.

When one considers that the owners of the know-how, the complementary assets, and the IP may all be different, the gains from innovation are also affected. A fourth possible role (which will be discussed later) is that of the orchestrator of these different assets. The gains from innovation are likely to be allocated among the four asset owners. Here is a brief description of each:

- *Knowledge Assets* – this is the product and process knowledge needed to effect the innovation. These can be embodied in physical artifacts and processes as well, but they often have a significant tacit component, and are hard to transfer.
- *Complementary Assets* – these are the assets needed to commercialize the innovation, to bring it to market effectively. These may be generic in character, specific, or co-specialized (Teece, 1986). Examples of such assets include manufacturing and distribution assets, as well as a brand.
- *Intellectual Property* – this refers to the patents, trade secrets, and copyrights that are relevant to the ability to practice the innovation. In the case of patents, if it includes a blocking patent, then such IP conveys the ability to exclude the owners of the other assets from making, using, or selling the infringing items.[7]
- *Orchestration Capabilities* – these are the abilities to orchestrate the above assets in a coherent way, such that the innovation can be commercialized effectively, and will not be blocked. Done well, the orchestrator can assure itself of the gains from innovation, and even discern future paths for profitable innovation. Without proficiency here, the innovating firm may lose, even it is well positioned with regard to complementary assets and know-how.

[5]As Lanjouw and Lerner (2001) discuss, the high costs of patent litigation can 'tilt the table' for less financially endowed competitors. Plaintiffs, for example, often file for preliminary injunctive relief, which seeks to force a defendant to cease production of the offending item, pending the outcome of litigation. This can cause significant damage, even if the eventual outcome is favorable to the defendant.

[6]Of course, misappropriation is only effective if you're not caught. Two years ago, an arbitrator ruled that Caterpillar Inc. had willfully misappropriated the intellectual property from a research joint venture with Clean Fuels Technology Inc. (CFTI) and then transferred that IP to another joint venture with Lubrizol Corp. without the knowledge of CFTI. Unfortunately, CFTI was able to discover the misappropriation, and successfully pursued a remedy. See 'Caterpillar is Found to Have Defrauded Ex-Partner Over Clean Fuels Technology', *Wall Street Journal*, January 19, 2000.

[7]Not all the focal innovation may be covered by IP, and what portion is covered may or may not block others. Frequently, it is possible to invent around or design around the claims covered by the IP. This is an essential element of appropriability in Teece (1986).

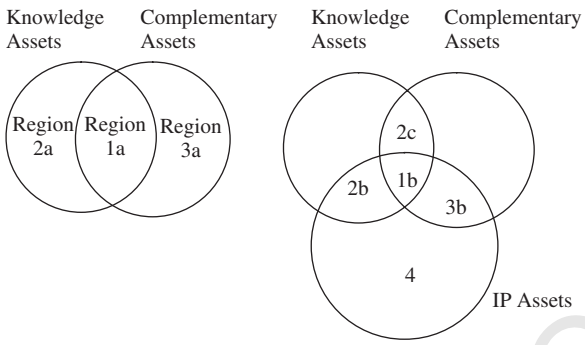


FIGURE 11.2 Underlying assets supporting innovation.

The first three of these elements are combined visually on the left side of Figure 11.2, which separates the elements so that they intersect, but do not overlap entirely with each other.

A firm's knowledge assets are shown in the circle on the left, while the complementary assets needed to commercialize the technology effectively are shown on the right. At least three conditions are possible:

- In Region 1a, the firm's knowledge assets coincide with the firm's complementary assets, and it is here where the firm can successfully profit from its innovation.
- In Region 2a, the firm has the knowledge assets, but lacks the complementary assets necessary to commercialize the technology. It is here where many firms fail to profit from their innovation activities.
- In Region 3a, the firm lacks the knowledge assets, but possesses the complementary assets. This firm has the opportunity to be a successful follower, because of these latter assets. Alternatively, the firm could contract with a firm in Region 2a, and extract a healthy portion of the rents from the innovation.

In a related analysis, Chesbrough and Teece (1996) argued that when firms possessed relevant complementary assets, 'virtual' outsourcing of particular technologies may be 'virtuous', because the firm would not have to negotiate for access to the requisite complementary assets to commercialize an externally accessed innovation. This stood in contrast to Region 2a, where outsourcing the innovation was argued to be hazardous.

Subsequent empirical work by other scholars has extended upon these insights. Tripsas (1997) showed how complementary assets assisted firms in navigating the complex technology transitions that arose in the typesetting industry over a period of a hundred years. Silverman (1999) provided a rigorous empirical methodology that predicted diversification moves by corporations into new businesses, based on the presence of complementarities between the old and new business. This empirical work, though, follows Teece (1986) in paying little attention to the potential separation of IP ownership from knowledge or complementary assets.

The right side of Figure 11.2 shows that conceptually, the technology or innovation is separable from the underlying IP that is relevant to practicing the technology. Regions 1b, 2b, 2c, and 3b are areas where untangling these concepts extend the earlier insights in profiting from innovation. As we will discuss, under certain conditions *a firm's complementary assets can become a hostage that confers additional leverage upon the IP holder.*

- In Region 1b, all three concepts are aligned within the firm. The firm possesses the technology, the associated IP, and the requisite complementary assets. This represents an effective orchestration of the requisite elements. Here, the prediction of the Teece (1986) article is again borne out: the firm can expect to profit from its innovation investments in this region.[8]
- In Region 3b, the firm lacks the technology, but owns the relevant IP and requisite complementary assets. Here, the firm is in a strong position to access the missing technology from outside the firm, and then take it to market. As noted in Chesbrough and Teece (1996), here, virtual is indeed virtuous. The firm need not invent the technology, or even possess the knowledge assets to drive the technology's development, in order to profit from it.
- In Region 2b, the firm has the knowledge and the IP, but lacks the complementary assets. As above for region 2a, the firm must negotiate access to the requisite complementary assets. Failure to gain such access on reasonable terms could again thwart the firm's ability to commercialize its innovation.
- In Region 2c, by contrast, the firm has the knowledge and the complementary assets, but lacks the IP associated with the innovation. Here, contrary to Teece (1986), *the firm is actually at risk of holdup or expropriation from the IP owner, even though it controls the requisite complementary assets.* If the IP owner is in region 4, lacking the technology and the complementary assets, it may nonetheless be positioned to use the IP to extract rents from the innovator. Indeed, the presence of complementary assets held by the innovator in region 2c *adds to the leverage of the IP holder* over the innovating firm.

This last conclusion requires some analysis. Assume that firm C has the technology and complementary assets necessary to commercialize the investment. However, firm D owns the legal rights to the IP that are embodied in the technology.Firm D can not only extract the rents from the technology itself, but also extract an additional amount from Firm C amounting to the specialized portion of the latter firm's complementary assets. This specialized portion, shown in Figure 11.1 as the quasi-rent, is at risk, if another firm can assert its IP rights over innovations that the complementary asset supports. The remaining value of the complementary asset is not at risk, because the asset could be placed in its next best use by firm C and continue to earn that level of value.

[8]In Teece (1986), the firm would utilize its own technology and supply it in the product market. Left unexamined is the additional possibility of whether the firm might also profit from licensing its technology to other firms who also possess relevant complementary assets. Arora *et al.* (2001) examine this possibility, and find that the firm must balance the *revenue effect* from additional receipts for its technology against *the rent dissipation effect* from increased product market competition downstream. A related treatment of these issues can be found in Chesbrough (2006), chapters 3 and 4.

In Williamson's (1985) terms, the quasi-specific value of the complementary asset serves as a hostage, which could be forfeit if the innovator was blocked by the IP owner's claim. The more firm C has invested in the specialized portion of its complementary assets, the greater the quasi-rent from deploying that asset to best advantage, and hence the greater the leverage firm D has over it in a negotiation about appropriating the rents from innovation.

If it has not obtained access to the technology in advance, Firm C is at substantial risk of losing the investments it has made in pursuit of innovation to the owners of the IP (here, firm D) whose claims 'read on' the innovation. The amount at risk could be quite substantial, as much as the total expected profits from the innovation, plus the quasi-rents from any specific investments B has already made to support that stream of profits.[9] To the extent that there are alternative technology suppliers, the presence of these feasible alternatives constrains the ability of D to hold up firm C. Even here, though, the switching costs for C also confers some market power on D. To the extent that endogenous investments in complementary assets increase quasi-rents and switching costs for C, they actually impair C's ability to profit from its investments.

Although this analysis has considered the context of intermediate technology markets as an instance where such hazards could arise, there are other contexts in which these considerations occur as well. One example is the 'submarine patents' held by IP owners such as Jerome Lemelson. Here, there may be little or no real contribution to know-how to practice the technology, but through strategic maneuvering the IP owner nonetheless has obtained a valid claim. If the claim is found to be valid, the division of rents from an innovation would have to include compensation for use of those assets.

## Orchestrating Appropriability

The foregoing analysis suggests the emergent need for a new role that was previously latent in appropriating the gains from innovation: the orchestration role. As defined above, this role brings together the requisite know-how, IP, and complementary asset classes, so that the innovation investments made lead to an acceptable return. This role includes a capability for systems integration, in understanding the possible ways that the technical components of a technology might be put together, both from current and possible alternative suppliers.

At a mundane level, orchestration might simply be viewed as checking to be sure that one owns or has effective access to the requisite know-how, IP, and

[9] In 1990 Eastman Kodak paid $909 million in damages (including interest) to Polaroid for its 1986 conviction for infringement of several of Polaroid's instant camera patents. This included treble damages for 'willful' infringement. Kodak's loss to Polaroid stands as the largest single judgment awarded to an IP holder in US court. Polaroid's patents were blocking patents in the instant camera market, but this was not clear (to Kodak, at least) at the outset – an example of the *ex ante* ambiguity of patent claims. But Kodak's total loss exceeded even this amount, because Kodak was forced to repurchase all of its channel inventory, and rebate the purchase price of its cameras to consumers who bought the infringing camera. Kodak's distribution capability (a complementary asset) ended up increasing the total cost to Kodak of infringing Polaroid's patents, by increasing the number of units of channel inventory that had to be repurchased.

complementary assets. If one or more of these assets is not readily at hand, however, the orchestration role becomes more strategic. In essence, the orchestration role must seek to offset or neutralize ones' own complementary assets as a hostage, in the bargaining over the gains from Schumpeterian innovation. Without such a role, the Teecian prescription of advising innovators to focus on accessing complementary assets may be overturned.

Although orchestration strategies could apply equally to all three classes of assets discussed, we focus here on how an alert orchestrator could seek to offset or neutralize advantages held by independent owners of IP. Below we sketch five orchestration strategies, which are not intended to be exhaustive, but do illustrate the wide range of options available to the innovating firm:

- countersuit;
- cross-licensing;
- voluntary divestiture of downstream operations;
- providing safe harbor;
- pre-emptive publishing.

*Countersuit.* In the example above, Firm C may consider the possibility of countersuit against firm D, owing to the ambiguity of protection over the IP at issue. It may well be that Firm C can mount a plausible action against Firm D, because the scope of D's patent claims is not entirely clear, and/or Firm D's operations (in this or another business) may be alleged to infringe on some other IP held by firm C. And if Firm D also possesses complementary assets to support its own product market activities, those latter complementary assets may then serve as a hostage against Firm D's interests, offsetting firm C's complementary assets at risk from the initial suit.

*Cross-licensing.* Cross-licensing is a well-known strategy for realizing design freedom (e.g., Grindley and Teece, 1997; Shapiro, 2000; Hall and Ziedonis, 2001). In many complex technologies, though, the costs of design are dwarfed by the costs of the requisite complementary assets to commercialize the design – a fact not yet recognized by strategy scholars.[10] In such instances, firms' cross-licensing may have less to do with seeking design freedom for its developers, and more to do with realizing the ability to utilize their own specific complementary assets to their best use in future. Their ability to continue to use their specialized complementary assets could be at risk if others can exert IP claims against the firm. This is an additional reason why competing firms (each with significant complementary assets) often seek out cross-licensing arrangements, a reason not previously noted in the literature. Cross-licensing confers the freedom to employ one's own complementary assets to their best advantage, reducing the chance that they can be used by an IP owner against the firm.

The cross-licensing analysis is more intriguing if there is an asymmetry in the complementary asset positions of the two competing firms. If firm C possesses significant complementary assets, while firm D does not, firm C faces the asymmetric

[10]For example, a new microprocessor design may require a few hundred human years of time, for a cost of a couple of hundred million dollars. However, the fabrication facility to make the design might cost ten times that amount.

threat of losing the quasi-specific value of its complementary assets, while firm D simply calculates its probability of winning or losing a litigation action against firm C. In this instance, *D's weakness* (its lack of the requisite complementary assets to profit from innovation) *turns into strength*, because it improves firm D's bargaining position over firm C. Firm C's strength, its ownership of key complementary assets, similarly becomes a liability, because firm D gains leverage in a negotiation with firm C due to the specialized character of C's complementary assets.[11]

*Voluntary divestiture.* This suggests a novel third orchestration strategy of voluntary divestiture of downstream operations. In the example above, Firm C might choose to spin off or discontinue downstream operations that employed its complementary assets, and become a competing technology supplier to firm D. A specialized 'technology supplier' firm that owns valuable IP, but lacks any operations or complementary assets, might actually be a superior organizational mode for pursuing a rent extraction strategy against innovating firms in a weak appropriability regime.[12] Such a specialized supplier voluntarily would eschew these downstream activities, in order to avoid having them be targeted by the party they wish to sue in a countersuit.

Consider the case of Qualcomm in the wireless telephony marketplace. Qualcomm used to be a manufacturer of telephone handsets and equipment as well as semiconductor chips used in phones. Its differentiation in the market was based on its CDMA technology, and Qualcomm became a licensor of the technology, to try to make it a *de facto* standard. In the past three years, Qualcomm has shifted its strategy to focus exclusively upon its CDMA technology, and leverage it to become the key standard in next generation wireless communications. The company intends to make money from licensing its IP for its CDMA and related technologies. In the process, the company has chosen to divest itself of all its product operations in handsets. When Qualcomm announced these moves, analysts attributed this withdrawal to Qualcomm's inability to fund its technology development as well as its products.

Be that as it may, our analysis suggests an additional motivation for why Qualcomm voluntarily withdrew from the product market: to maximize its bargaining position in the upstream IP market. Qualcomm's products competed in an environment of complex or cumulative technologies (Nelson and Winter, 1982; Pavitt, 1999), where one technology builds upon other, closely related technologies. In order to participate in selling handsets and chips, Qualcomm had to make significant investments in a number of technology and complementary assets. It is difficult in this industry to have 100 % ownership of all the IP involved in the products one builds. Qualcomm could not be sure that its downstream products would not infringe to at least some degree upon other companies' IP, particularly the IP of other companies in the telecommunications market.

[11]There are a number of testable propositions emerging from this section. We predict that, in a weak appropriability regime, greater levels of complementary assets held by both parties would lead to a greater likelihood of cross-licensing. We also predict that, again in a weak appropriability regime, if significant asymmetries in complementary assets exist, revenues in any cross-licensing for a given amount of IP (or holding IP constant) would flow towards the party with the lesser amount of such assets.

[12]Here we depart from Gans, Hsu, and Stern (2002), who find that the 'cooperative strategy' of licensing to a downstream business is more likely when appropriability is strong, and less likely when weak. We argue that the firm has a third option in a weak appropriability regime, the option of divesting itself of its own operating assets to enhance its bargaining power.

The ambiguity of IP claims, the complex nature of the underlying technologies, and the significant investments in technology and complementary assets, all impaired Qualcomm's ability to maximize its profits from its IP. If Qualcomm wished to maximize the revenues it could earn from licensing its CDMA technology, it would gain more leverage in its negotiations with other handset manufacturers if it deprived them of a chance to countersue for infringement of their own IP in the handset market. Qualcomm's withdrawal from making handsets allowed it to remove potential hostages from negotiations over its CDMA technology, thereby strengthening its negotiating position in the upstream market.

A second example of this orchestration strategy comes from Rambus, an innovative designer of dynamic random access memories (DRAMs) in the semiconductor industry. The semiconductor industry is one studied by many scholars, and one where cross-licensing and defensive patenting has been extensively reported (e.g., Cohen, Nelson, and Walsh, 2000; Hall and Ziedonis, 2001). Rambus has designed – and carefully built a wall of patents around – a chip-to-chip interface that speeds the flow of data into and out of the DRAMs, alleviating the bottleneck of DRAMs in personal computer system performance. The company's business model is *not* to enter into manufacturing of devices using the Rambus design; instead, the goal is to license its technology to other companies.

Rambus' organizational mode cleverly places it in a position to avoid having to water down the strength of its IP claims by trading those for access to other IP it would need to compete as a manufacturer of DRAM devices. It also avoids having to raise the capital to finance or access complementary assets in manufacturing Rambus-enabled DRAMs, assets that ironically could compromise its negotiating leverage in the IP market. Its strategy is likely to lead to far greater revenues from its IP than it would have obtained, had it chosen to enter into the downstream product market as well.

*Safe harbor.* A fourth orchestration strategy is to use one's complementary assets and IP to provide a safe harbor to innovation partners, in order to protect the latter's innovation against countersuits by other parties. Tensilica is a new entrant in the microprocessor market (Chesborough, 2003, chapter 8). It has an innovative technology to permit low power operation, and field programmability of its device. But the company lacks much of the surrounding IP needed to manufacture microprocessors. Intel, by contrast, has a much stronger IP portfolio, and has demonstrated its willingness to litigate aggressively with its portfolio to deter entry into its microprocessor markets (Jackson, 1997). When a startup company such as Tensilica wants to compete with a powerhouse like Intel in the low-power microprocessor market, it has to worry a great deal about Intel's ability to impair its business through the threat of patent infringement litigation. Given the complexity of microprocessors, and the complexity of their manufacture, it is difficult at best to assure a young startup's investors, as well as its intended customers, that the startup's activities will not infringe another company's IP rights. How can Tensilica resolve this uncertainty, and convince its investors and customers to support its innovative efforts?

They resolved this problem by finding a safe harbor through working with IBM, a partner with an even better semiconductor IP portfolio than that of Intel. IBM agreed to serve as Tensilica's foundry, to make its devices. IBM has a wonderful portfolio of semiconductor patents, earned over many years of R&D in the industry. IBM has leveraged this portfolio to enter into cross-licensing agreements with virtually all the major industry players (including Intel), often receiving payments, in addition to access to other companies' IP in return for access to its own. This network of agreements and strong internal IP makes IBM a safe foundry for younger companies seeking to enter into the industry. IBM is likely to earn a healthy margin acting as Tensilica's manufacturer. And that margin consists not only of a return to IBM for its manufacturing expenses in the capital-intensive production of semiconductors, but also of a margin in return for providing Tensilica an IP insurance policy.

*Pre-emptive publishing.* A final and very different orchestration strategy for complementary asset holders would be to pre-empt IP holders by proactively publishing one's knowledge, in order to create an intellectual commons. Creating such a commons would forfeit the chance to capture value from one's own IP, but it similarly could prevent another firm from extracting IP rents from one's own operations and complementary assets. If one has sufficiently strong complementary assets and technology, one may be able to win in the market without owning the IP, so long as no one else can stake that claim, and block the firm from leveraging its assets in pursuing future innovations.

The Intel Corporation actively sponsors university research in a number of areas of technological interest to the firm.[13] It also spends many billions of dollars each year in R&D, to create critical complementary assets such as the latest generation semiconductor fabrication facilities, sales and marketing, and advertising. At the time of writing, Intel owns and operates more semiconductor fabrications facilities (known as 'fabs') than any other company in the world. Intel goes to great lengths to ensure that its fabs can keep operating.

This philosophy animates Intel's approach to funding university research. Intel does not prevent its funding recipients in universities from publishing; indeed, it encourages publishing, because the published results cannot then be patented by other firms, and used to exclude Intel in its operations.[14] Intel also maintains the *Intel Technical Journal*, which it publishes precisely to establish particular discoveries in the public domain, where they cannot be used against Intel's large and growing complementary asset base.

Intel's approach to allowing its funding recipients to publish their knowledge, and its sponsorship of its own journal to publish some of Intel's own knowledge, deprives Intel of the ability to extract rents from the use of that knowledge. However, Intel may be willing to forfeit these opportunities in the upstream technology market, if by publishing this knowledge it increases the chance that its extensive complementary assets may continue to be employed to commercialize new semiconductor products. If Intel can 'win' in the product market by virtue of its complementary assets, it can afford to play for a 'tie' in the upstream IP that utilizes those assets.

## Conclusion

We began by re-examining the question that prompted David Teece in his exploration of complementary assets: why do some firms profit from their innovation investments, and others not? The emergence of intermediate markets for technology gives a new importance to this question, both for antitrust policy, and for firm strategy. Particularly for the latter concern, the rise of intermediate markets creates situations where the ownership of the IP that undergirds a technology may *not* align with the ownership of the requisite complementary assets needed to practice the technology.

Such situations render the appropriability of innovation investments potentially problematic, even when the innovator owns or has access to the requisite complementary assets. For now the innovator must also own or gain access to the requisite IP assets as well, in order to profit from its innovation investments. There are strategic dimensions involved in gaining this access, and alert innovators must take steps to neutralize the threat that an alert IP owner may pose. One result of these strategic issues is that the ownership of complementary assets may confer leverage of the IP owner, unless steps are taken to neutralize that leverage. A variety of orchestration tactics are sketched, to illustrate the range of potential problems that this alignment of IP may entail, as well as the steps companies are taking to address them.

Once we begun to ponder these orchestration moves, we come to understand that the appropriability of innovation investments is at least partially endogenous in its character. Although industry characteristics or other exogenous factors may influence the appropriability of an innovator's investments, there are also factors under the innovator's control that must be brought to bear as well. We should expect to see significant variation in appropriability within industries, in addition to variation between industries. And we should not be surprised if innovators with complementary assets sometimes fail to profit from their innovation investments, when competing in industries with active intermediate markets.

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